BRYOPHYTES IN THE 1969 CRATER OF DECEPTION ISLAND, ANTARCTICA: AN APPARENT CASE OF RAPID LONG–DISTANCE DISPERSAL[1, 2]

STEVEN B. YOUNG AND JEAN-ROLAND KLÄY

Institute of Polar Studies, The Ohio State University, 125 South Oval Drive, Columbus, Ohio 43210

ABSTRACT

Specimens of *Marchantia polymorpha*, a thallose liverwort, were found on newly exposed ground in the crater formed by the 1969 volcanic eruption occurring on Deception Island, Antarctica. The nearest known source of propagules of this species is in South America, c. 1,000 km distant. Numerous propagules must have arrived on a small area of Deception Island in the recent past. *Marchantia polymorpha* appears to have great dispersal potential. Its absence in other Antarctic areas is probably the result of environmental rather than historical or geographical factors.

Deception Island (fig. 1) is part of the South Shetland Islands archipelago, a group of islands which lies off the northern tip of the Antarctic Peninsula. The island lies within the Antarctic vegetation zone, in which vascular plants are rare or nonexistent. However, many species of lichens, mosses, and liverworts occur in this zone, and they may be locally abundant. The climate of the area is polar maritime; mean temperatures are slightly above freezing during the austral summer (January and February), and winters are comparatively mild. Precipitation is comparatively heavy, mostly occurring as snow. As a result, most of the land in the area is covered by glacial ice.

Deception Island is one of two active volcanos in Antarctica, the other being Mt. Erebus on Ross Island, some 4000 km away in East Antarctica. In February, 1969, for the second time within fifteen months, a major volcanic eruption occurred on Deception Island. The main force of the eruption was concentrated in an ice-covered area on the east side of the island (fig. 1). As a result of the explosive force of the eruption and the melting of the ice cover, a series of fissures up to 60 m deep was opened through the glacier, exposing bare ground.

In early January, 1970, nine months after the eruption, one of the authors (Kläy) climbed into the northern end of the rift in the ice and found live vegetation there. On January 10, both Young and Kläy returned to the same location and collected specimens of plants. Collections were small, so that the spread of vegetation could be observed at a later date. The effects of a subsequent eruption (August, 1970) on the vegetation are not known.

At the time of the January, 1970, visit, the floor of the rift was rough and unstable; it was covered with ash, cinders, and larger pieces of volcanic debris. In many areas in and near the rift, ground temperatures were so high that material only a few centimeters below the surface was incandescent. Pieces of newspaper dropped on the ground soon burst into flames. Cooler soil was found along the edges of the rift. Here, large blocks of ice had fallen from the ice cliffs bordering the rift. The water supplied by the melting of this ice kept the soil comparatively cool and moist. Meltwater seeping into the hot ground also produced quantities of steam (fig. 2), so that a constant high level of humidity was maintained in some parts of the rift. Vegetation was found only in these areas of moist soil and high humidity.

The vegetation consisted of mosses and liverworts. At least two species of moss were found; exact identifications of the mosses could not be made because

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of the immature condition of the specimens. Some moss specimens belonged to *Tortula*, a common genus in the Antarctic and an important constituent of the vegetation of other parts of Deception Island (Collins, 1969). The other moss is a member of the Funariaceae and it is almost certainly the same species which Collins (1969) found near fumaroles at Telefon Bay on this island after the 1967 eruption. Mosses were rather uniformly distributed in one part of an area of

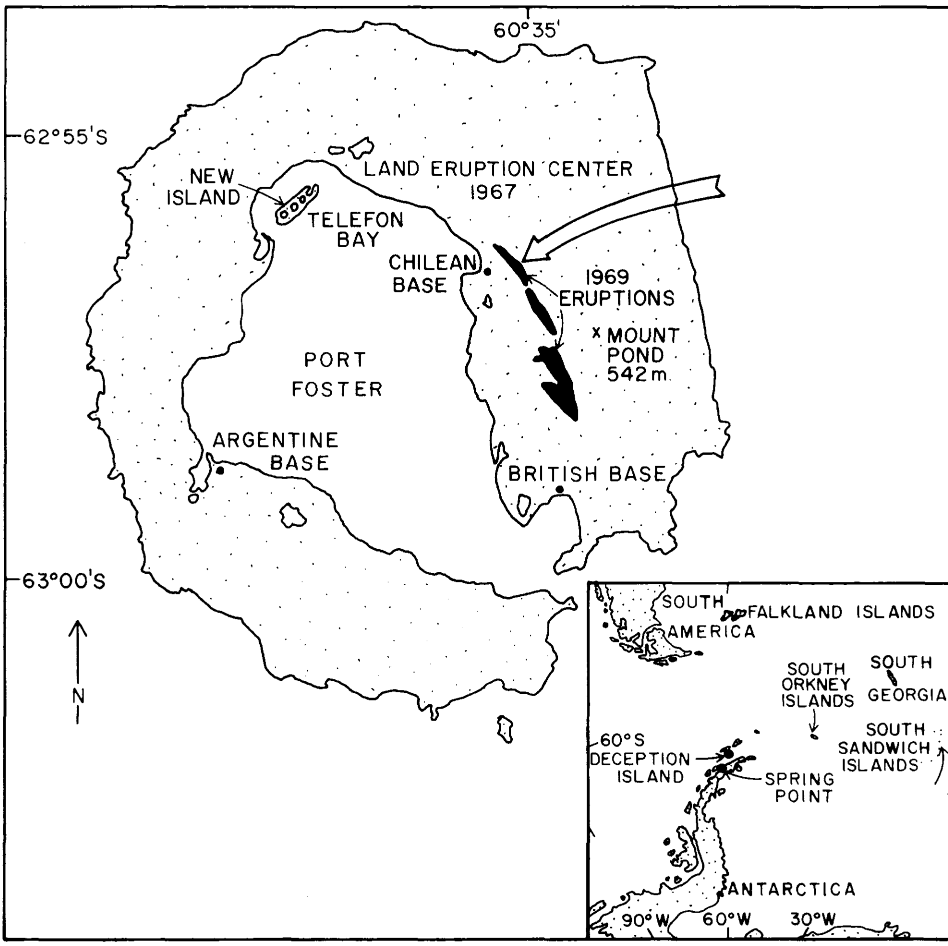

FIGURE 1. Map of Deception Island. Arrow points to approximate location where vegetation was found. Inset shows location of Deception Island. Arrows indicate locations where *Marchantia* is known to occur in the Antarctic zone.

about 20 m^2. There is no reason to doubt that the populations of mosses found in the rift were the result of colonization from other colonies of the same species already existing on Deception Island.

In addition to the mosses, approximately 20 individuals of the liverwort, *Marchantia polymorpha* L., were found in the same area of the rift floor. Specimens ranged from about 10 mm to about 25 mm long (fig. 3). None showed reproductive structures of any kind. In view of the short period of time that the habitat had been available and the lack of reproductive structures on the plants, it seems evident that each plant was the result of a separate case of dispersal.

FIGURE 2. Floor of the rift caused by the 1969 eruption on Deception Island. The scientist, J. R. Kläy, is pointing to the location of a specimen of *Marchantia polymorpha*. Note the quantities of steam, produced by meltwater coming in contact with hot volcanic debris.

Marchantia commonly reproduces by means of gemmae, multicellular asexual propagules which are produced in cup-like structures on the surface of the thallus. Gemmae normally have two meristematic areas at opposite ends. As a result, they germinate into young gametophytes with a characteristic dumbbell-shaped growth form (fig. 3). It is interesting that many of the *Marchantia* specimens from Deception Island have this form, indicating that at least some of the original propagules were gemmae rather than unicellular spores.

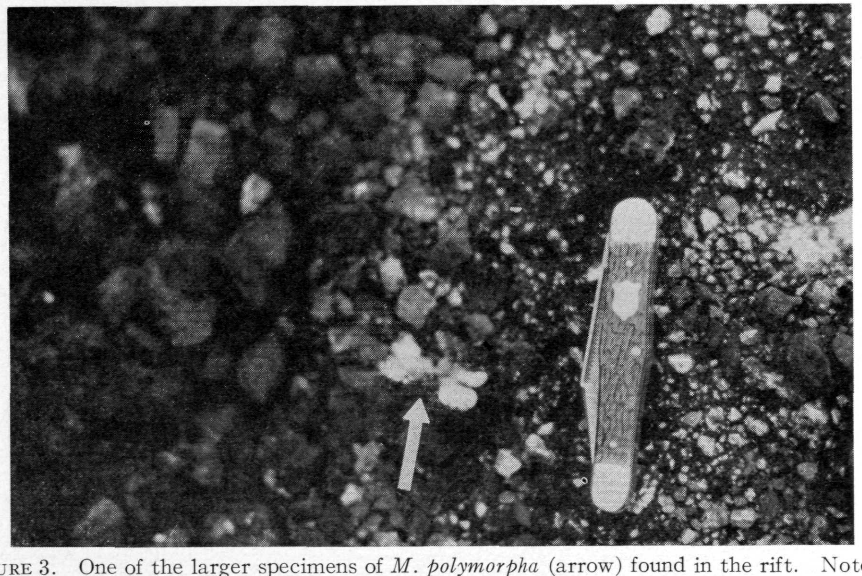

FIGURE 3. One of the larger specimens of *M. polymorpha* (arrow) found in the rift. Note the characteristic dumbbell-shaped growth form, indicating that the plant developed from a gemma. The knife is 10 cm long.

In the Antarctic zone, *Marchantia* has been recorded from Spring Point on the Antarctic Peninsula (Corte, 1962) and from the South Sandwich and South Orkney Islands (Gimingham and Smith, 1970). However, all of these records refer to *M. Berteroana* Lehm & Lindenb. *Marchantia polymorpha* is not known to occur south of the Fuegian region, nearly 1,000 km due north of Deception Island.

Deception Island is one of the more intensively studied areas in the Antarctic. It is unlikely that a conspicuous thalloid liverwort like *Marchantia* could have been established on the island before this observation without having been reported. It is probable that an almost infinitesimally small area of suitable habitat, which had been available for colonization for less than a year, was repeatedly bombarded by viable propagules of *Marchantia*, some or all of these propagules being multicellular gemmae.

The nearest likely source of these propagules was in southern South America, some 1,000 km distant. The chances of bird dispersal are extremely slight; there are no land birds in the Antarctic, and sea birds only come ashore to breed. The likelihood that any known species of bird in the area would be carrying *Marchantia* propagules, and would land in the middle of an active volcanic crater is very remote. In the absence of any evidence to the contrary, wind seems to be the most likely dispersal agent. However, the normal wind patterns in this part of the world would not favor the direct transfer of propagules from southern South America to Deception Island. Since *Marchantia polymorpha* is wide ranging in both the northern and southern hemispheres, New Zealand or one of the sub-Antarctic islands are more likely than South America to have been the source of the Deception Island specimens.

It is possible that the propagules landed on the ice cover of the island at some date before the eruption and were then deposited in the rift as a result of melting of the ice. The maximum amount of time since the dispersal of the propagules to the island would then depend on one of two factors: the amount of time that the propagules could remain viable while frozen in glacial ice, or the age of the oldest ice in the vicinity of the rift floor.

Data on the potential longevity of dormant propagules of hepatics is scanty. It is known (Schuster, 1966) that spores of *Marchantia polymorpha* that have been stored for 18 months have less than half the germination potential of fresh spores. Vegetative shoots of *Cephaloziella* from the Antarctic zone have been found to be capable of growth after having been frozen for a period of three years (Longton and Holdgate, 1967), but there is no evidence that the propagules of Hepaticae can live for long periods frozen in ice. There is no reason to believe that gemmae or spores of *Marchantia* would retain their viability while frozen in the ice for long periods.

Annual dirt layers in a portion of the rift somewhat deeper than the area in which vegetation was found indicate that the oldest ice there was probably deposited about 1900 A.D. (Orheim, 1970). On the basis of ice thickness and the annual layering visible on the sides of the rift, the oldest ice in the vicinity of the vegetated area is interpreted to be 15 to 30 years old. Even if the propagules were frozen in the lowermost layer of ice and were able to retain their viability under these conditions, it is unlikely that they could have arrived more than 30 years ago.

The effectiveness of long-distance dispersal is a major problem confronting biogeographers. If dispersal mechanisms are commonly effective over great distances, then gaps in distribution must be due to ecological factors which prevent the establishment of propagules that land in the area of the gaps. Conversely, if dispersal mechanisms are comparatively ineffective over great distances, wide-ranging species owe their distribution patterns to geographical and historical factors which have allowed the distribution patterns to become established with only minimal dependence on long-distance dispersal.

Although most distribution patterns undoubtedly result from a combination of ecological and geographical-historical factors, it is seldom possible to study the comparative importance of these factors. This is largely because there is so little data on the effectiveness of long-distance dispersal. "Target" areas are usually large and have been available for long and indefinite periods of time. Their present biotas are normally the result of complex interacting factors, of which long-distance dispersal is only one. The biotas can often be considered to be in a state of equilibrium which militates against the establishment of new elements, even if they are dispersed to the target (MacArthur and Wilson, 1967). There is no way of knowing how many viable propagules have unsuccessfully invaded the area in question.

Much of our knowledge of the effectiveness of long-distance dispersal comes from the study of new land resulting from volcanic activity. However, most classic examples of this situation (Krakatau, Katmai, Surtsey) are in areas in which a complex biota as a source of colonizers is available only a short distance away. The presence of *Marchantia polymorpha* in an extremely small, isolated, and recently formed habitat on Deception Island indicates that, at least in the case of this species, the potential for long-distance dispersal is great. The absence of this species in other nearby areas must be attributed to lack of adaptability to the prevailing environmental conditions, rather than to lack of dispersal potential. This indicates that dispersal mechanisms are often more effective than is commonly believed, and that the major barriers to the establishment of new species in a stable environment are commonly ecological rather than geographical in nature. This is in keeping with the observation that adventive species of plants are rare in high polar environments, even in cases where these areas have been subject to human habitation for long periods of time. Even if plants are dispersed to these areas through the activities of humans, lack of adaptability to the prevailing conditions prevents their establishment.

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LITERATURE CITED

Collins, N. J. 1969. The effects of volcanic activity on the vegetation of Deception Island. British Antarctic Surv. Bull. 21: 79–94.

Corte, A. 1962. Primera Cita de la Familia Hepaticas "Marchantiaceae" para la Antártida. Contr. del Instituto Antártico Argentino No. 68. 12 p.

Gimingham, C. H., and **R. I. L. Smith.** 1970. Bryophyte and lichen communities in the maritime Antarctic. *In* M. W. Holdgate, ed. Antarctic Ecology, vol. II. Academic Press, London and New York. p. 752–785.

Longton, R. E., and **M. W. Holdgate.** 1967. Temperature relationships of Antarctic vegetation. Phil. Trans. Royal Soc., B. 252: 237–50.

MacArthur, R. H., and **E. O. Wilson.** 1967. The Theory of Island Biogeography. Princeton Univ. Press, Princeton, N. J. 203 p.

Orheim, O. 1970. Glaciological Investigations on Deception Island. Antarctic J. of the U. S. 5: 95–97.

Schuster, R. M. 1966. The Hepaticae and Anthoceratae of North America, vol. 1. Columbia Univ. Press, New York. 802 p.